Variability of the Kuroshio in the East China Sea, and its Relationship to the Ryukyu Current

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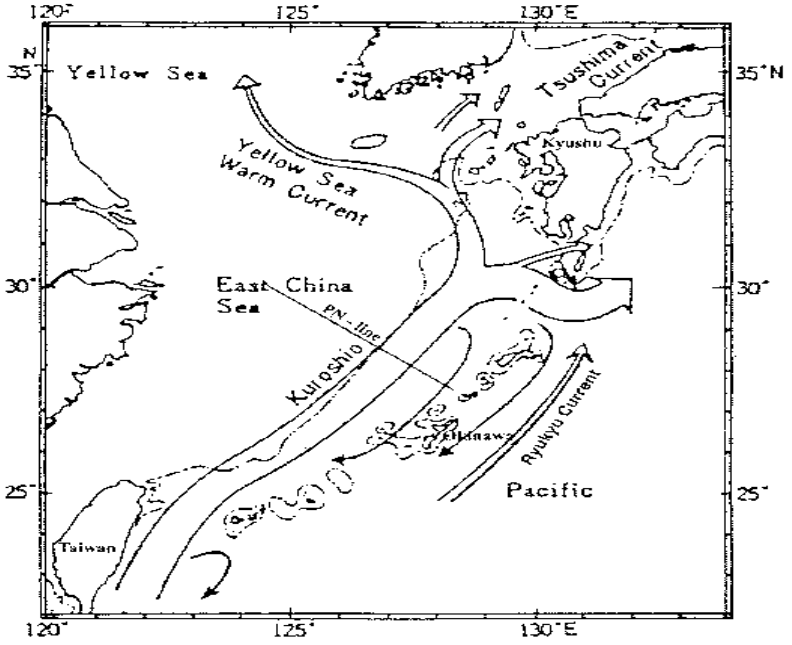
LONG-TERM GOALS

To characterize and understand (with our Korean and Japanese colleagues) the dynamics of the time varying structure and transport of the Western Boundary Current (WBC) system at 26^{O}–28^{O}N in the northwest Pacific Ocean, in particular the Kuroshio in the East China Sea (ECS), and the Ryukyu Current.



Schematic representation of the Western Boundary Current system near the Ryukyu Islands, including the Kuroshio and the Ryukyu Current, based on Nitani (1972).

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OBJECTIVES

On time scales ranging from two days to two years, our main objectives are the following:

(1) To observe the WBC variations near Okinawa on all relevant timescales, and, with ancillary information on wind forcing and arrival of offshore eddies, address a comprehensive set of hypotheses that have been proposed to account for the WBC structure and variability:

- that the combined WBC mean transport balances the average Sverdrup transport;
- that the phasing of the annual cycle in transport is lagged in a predictable manner from the seasonally varying Sverdrup transport, by the propagation of wind-generated Rossby waves from offshore;
- that variability in how the Kuroshio bifurcates upstream (off Taiwan) governs the proportion of transport that enters either the ECS Kuroshio or the Ryukyu Current;
- that eddies arriving at this WBC system from the ocean interior affect the upstream bifurcation and—as a result—the strength of these two currents.

(2) To measure the characteristic periods and phase speeds of Kuroshio meanders in the ECS and relate them to the strength of the transport.

(3) To investigate the relationship between the transports of the ECS Kuroshio and the Tsushima Current.

APPROACH

Deploying an array of inverted echo sounders with additional sensors in the Okinawa Trough to measure the time-varying current and temperature structure over a two-year time period, simultaneous with similar measurements to be made by Japanese scientists at the Japan Marine Science and Technology Corporation, Frontier Observational Research System for Global Change (JAMSTEC).

To determine temperature and specific-velocity-anomaly profiles from the inverted-echo-sounder measurements, we will use the Gravest Empirical Mode (GEM) technique (Meinen and Watts, 2000) which has been successfully applied to the Kuroshio 700 km further downstream (Book et al., 2002).

WORK COMPLETED

Under ONR (DURIP) support, we first modified our inverted echo sounder design to incorporate the Aanderaa 3820R current measuring head, and then, after field testing (see RESULTS section), began construction of 12 CPIES instruments (current-and-pressure-sensor-equipped inverted echo sounders). Six of these, together with five PIES instruments (pressure-sensor-equipped inverted echo sounders) belonging to NRL, were deployed in two lines, each near and parallel to the PN-line (see figure), in December 2002. This deployment was carried out in conjunction with Dr. Hiroshi Ichikawa and his associates from JAMSTEC on their ship, *R/V Yokosuka*. On the same cruise our JAMSTEC colleagues deployed a similar array under the Ryukyu Current, on the opposite side of the Ryukyu Island chain. We took hydrocasts at all deployment sites after the instruments were deployed.

RESULTS

To test our design for the CPIES instrument, we deployed a CPIES for one month off Bermuda in Spring 2002. The results showed very good agreement between current data obtained from the CPIES and those obtained from a conventional current-meter moored about one kilometer away.

The CPIES and PIES instruments will not be recovered until about December 2004, so the data recorded by them are not available until after that time. (The recovery cruise is expected to be on a Japanese vessel, as with the deployment cruise.)

IMPACT/APPLICATIONS

The results from this study should lead to advances in our understanding of WBC dynamics, in particular the dynamics associated with spatiotemporal variability of meanders and bifurcations. This knowledge should be applicable to the Kuroshio at other latitudes, and also to other WBC's.

TRANSITIONS

Since our work is at a preliminary stage, others are not yet able to make use of our work on this project.

RELATED PROJECTS

(1) The Korea Ocean Research and Development Institute (KORDI) is supported by ONR/NICOP to deploy ADCPs on the outer continental shelf near the PN-line in a project titled "Kuroshio Variability on the Shelf in the East China Sea." These instruments will record the part of the Kuroshio transport which flows over the shelf. Dr. Kyung-Il Chang of KORDI is carrying out the ADCP deployments now (September 2003) and plans to maintain the moorings during most of the time from the present until the end of 2004.

(2) The JAMSTEC "Kuroshio Observation Project" (KOP) focuses on understanding the barotropic and baroclinic components of the WBC on either side of Okinawa, in the Ryukyu Island Chain. The JAMSTEC array is on the southeastern side of Okinawa, under the Ryukyu Current. Our array is on the northwestern side in the ECS Kuroshio.

(3) Dr. Kuh Kim of Seoul National University, Korea has calibrated the voltage measured on a cable across the Korea/Tsushima Strait and is thus able to measure the time varying Tsushima Current transport while our array is deployed.

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